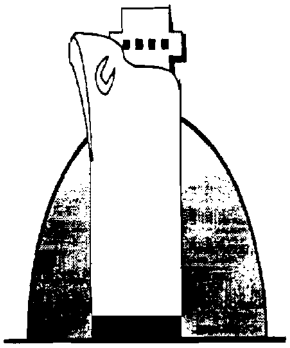
Meeting Agenda

Wednesday:

1:30 PM	Introduction and project review *Bob Bea*
2:00	ULSLEA updates (fatigue, earthquake, additional configurations) *Jim Stear*
3:00	Discussion
3:15	Break
3:30	Sponsor Presentations
4:00	Discussion
4:30 PM	Conclude

Thursday:

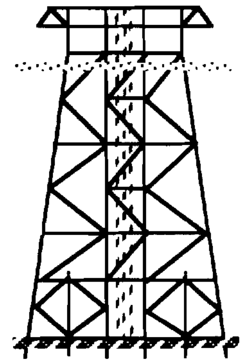
8:00 AM	Review issues from previous day *Bob Bea*
8:30	ULSLEA enhancements, demonstration *Jim Stear*
9:30	Future work plan *Bob Bea, Jim Stear*
10:00	Discussion, sponsor's directions
11:00 AM	Adjourn



1997 - 1998

MARINE TECHNOLOGY & MANAGEMENT GROUP

INDUSTRY & GOVERNMENT AGENCIES SPONSORED RESEARCH PROJECTS SUMMARIES



Professor Robert Bea
College of Engineering
Tel: (510) 642-0967
Fax: (510) 643-8919
e-mail: rgbea@euler.berkeley.edu

Professor Karlene Roberts
Haas School of Business
Tel: (510) 642-5221
Fax: (510) 631-0150
e-mail: karlene@haas.berkeley.edu

215 McLaughlin Hall
UNIVERSITY OF CALIFORNIA
Berkeley, CA 94720-1712

Goal: Develop engineering and management technology that will help improve the QUALITY (safety, serviceability, durability, compatibility - economy) of marine systems

RESEARCH AREAS

Human & Organization Factors

Ships & Floating Systems

Platforms & Pipelines

Human and Organization Factors	**Researcher**	**Goals and Objectives**
FLAIM II (with Prof. Williamson, Prof. Roberts, Paragon Engineering Inc.)	Derek Hee	Develop a comprehensive system to evaluate the life-cycle reliability characteristics of ships including human factors considerations. Validate system with Estonia accident analysis. MMS
Management of Rapidly Developing Crises: A Multi-Community Study	Bob Bea, Karlene Roberts	Develop a real-time system to assist in arresting rapidly developing sequences of events that can lead to catastrophic accidents.
Human & organization factors in diving operations	Shawn Cullen	Promote dive safety through identification, analysis, and management of human and organization factors in diving operations.
Human & organization error risk reduction assessment instrument - SMAS	Brant Pickrell	Develop, code, and verify a computer program for use in assessing the risks of human and organization errors in operations of offshore platforms and marine terminals.
Safety Management Assessment System - SMAS (with Profs. Brady Williamson and Karlene Roberts)	Derek Hee	Develop a two-level assessment instrument to help qualified assessors evaluate human and organization performance in operations of offshore platforms and marine terminals.
Human & organization factors in quality of offshore platforms (with Atkins, Ramboll, and MSL Eng.)	Rich Lawson	Develop a computer program to facilitate analyses of human and organizational factors in the life-cycle quality performance of offshore platforms MIN. STRUCTURES MMS
Human and Organizational Factors in Emergency Medicine	Karlene Roberts	Develop and implement research in seven medical units, ranging from paramedic units in fire deaprtments to adut and child critical care units. This research tests a model of risk mitigation. Other investigators participating in this research include
Center for Risk Mitigation - CRM	Bob Bea, Karlene Roberts	Organize a research center that will provide a forum for research and information exchange among diverse industries to improve the safety of high technology systems Possib MM

SMAS - SAFETY MANAGEMENT ASSESSMENT SYSTEMS

Ships, Platforms, Pipelines	Researcher	Goals and Objectives
Ship Structural Integrity Information System - SSIIS III	Henry Reeve	Develop and verify one component of a comprehensive ship quality information system that addresses the structural aspects of ships over their life.
Design and construction of long-life marine composite structures	Paul Miller	Develop and test panels of marine composites subjected to repeated loadings in submerged conditions. Develop and verify an analytical procedure to allow the evaluation of the long-term performance characteristics of marine composite panels.
Optimal strategies for the inspections of ships and offshore platforms for fatigue and corrosion damage (with Martec, Inc.)	Tao Xu	Develop procedures and strategies to optimize the inspection and repair of ship and offshore platform structures. The inspection strategies will address predictable damage (e.g. fatigue of critical structural details) and unpredictable damage (e.g. due to accidents and errors).
Reassessment & Requalification system for offshore platforms (Prof. Bill Ibbs, Principal Investigator)	Steve Staneff	Develop a computer based information and data management system for the reassessment and requalification of fleets of offshore platforms.
Ultimate Limit State Limit Equilibrium Analyses of template-type offshore platforms - ULSLEA Phases 3 and 4	Jim Stear, Zhaohui-Jin, Pending Assignment	Continue development and verification of a simplified procedure to characterize the ultimate limit state loadings and capacities of offshore platforms and their reliabilities for extreme condition storms and earthquakes.
Analyses of the nonlinear performance of platforms and caissons subjected to hurricanes	John Kareolis, James Wiseman	Continue study of the performance characteristics of platform and caisson systems when the storm loadings force the structures to their ultimate limit states.
Performance of pile foundations subjected to earthquake excitations (Profs. Seed, Bray, Pestana)	Philip Meymand, Thomas Lok, Chris Hunt	Develop and verify analytical models to assess the performance characteristics of groups of piles supporting structures subjected to intense earthquake excitations. Perform shaking tests on model pile groups to provide test data to verify the analytical models.
Pipeline Integrity and Maintenance Information System - PIMPIS	Tarek Elsayed	Develop and verify an inspection and maintenance decision support system for submarine pipelines using a knowledge-based approach. PIMPIS will provide a means of embedding expert knowledge to help select options for pipeline inspections and maintenance.
Platform, pipeline, and floating systems design and requalification criteria for the Bay of Campeche	Tao Xu, Zhaohui-Jin, Pending Assignment	Develop and verify a general platform and pipeline design and reassessment - requalification system tailored to the unique environmental, operational, and economic characteristics of PEMEX operations in the Bay of Campeche.
ISO earthquake guidelines for design and reassessment of offshore platforms	Bob Bea, Pending Assignment	Continue development of reliability based platform earthquake design and reassessment guidelines for the International Standards Organization.
Reliability based earthquake LRFD design guidelines for offshore Indonesia	Bob Bea, Pending Assignment	Develop platform load and resistance factor design guielines for offshore Indonesia
Decommissioning and re-use of offshore platforms	James Wiseman, Brian Collins	Develop a general process for the assessment and evaluation of alternative procedures for the decommissioning of offshore platforms . Assist in conduct of MMS / CSLC workshop on decommissioning.

MMS

MMS

MMS

Univ. of ...

MMS

MMS

Screening Methodologies for Use in Offshore Platform Assessments and Requalifications

Project Objective:

Further develop and verify simplified quantitative screening methodologies for Level 2 platform assessments so these methodologies may be used in practice

Phase I: June 1993 to May 1995

Phase II: June 1995 to May 1996

Phase III: June 1996 to May 1997

Phase IV: June 1997 to May 1998

Phase IV Project Sponsors

ARCO Exploration and Production Technology

Exxon Production Research Company

Mobil Technology Company

Shell Offshore Incorporated

Unocal Corporation

New Sponsors:

US Minerals Management Service

PeMex/IMP

Potential Sponsors:

Chevron Petroleum Technology Company

Phillips Petroleum Company

Saudi Arabian Oil Company

Phase IV Deliverables

#1

Documentation of ULSLEA program enhancements, comparisons, developments, evaluations, and verifications

#2

Updating of ULSLEA user and modeling guide, including updated software and coding

#3

Two meetings

ULSLEA Phase I

- Aero and hydrodynamic loadings ✓
- Unbraced deck legs capacity ✓
- Jacket capacity (legs, braces, joints) ✓
- Foundation capacity ✓
- Deterministic ULS analysis ✓
- Probabilistic ULS analysis ✓
- Damaged and grout-repaired members ✓
- Verification case studies (5) ✓ (NOTE)
- ULSLEA program documentation ✓
- Meetings (2) ✓

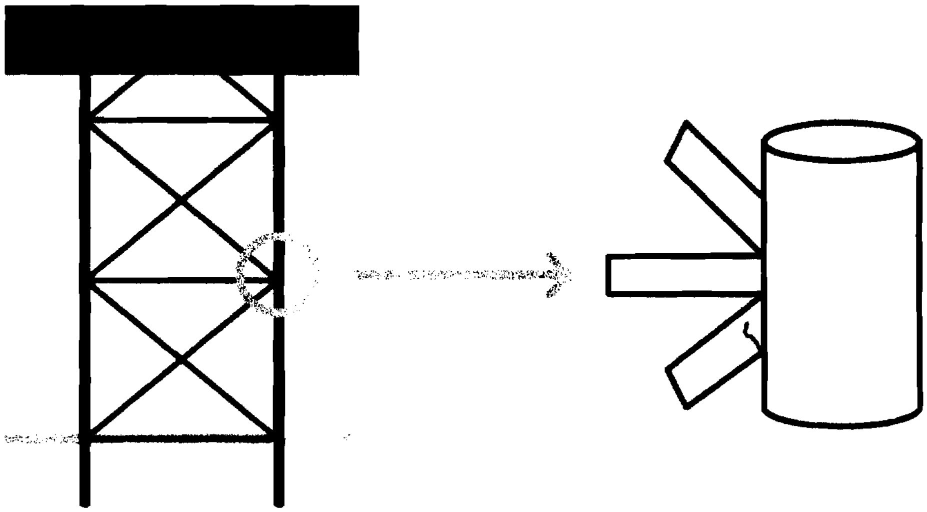
ULSLEA Phase II

- Modeling enhancements ✓
- Code updating and enhancement ✓
- Preliminary design of braces ✓
- Jacket horizontal framing effects ✓
- Additional verifications (2) ✓
- Linear analysis comparisons ✓
- User - modeling guide ✓
- Reporting and documentation ✓
- Meetings (2) ✓

ULSLEA Phase III

- Fatigue analysis algorithms ✓
- Earthquake analysis algorithms ✓
- Verifications of earthquake analysis (3) ✓
- Earthquake deck spectra ✓
- Additional configurations ✓
- Platform strength and robustness studies ✓
- Code updating ✓
- Reporting and documentation ✓
- Meetings (2) ✓

Fatigue Analysis with ULSLEA



Long-term wave heights

↓

Correlate wave loads to joint stresses

↓

Compute fatigue damage

$$Y_0=\frac{N_0}{T_{spectrum}}H_0^{g_{stress}m}\left(\ln N_0\right)^{\frac{-g_{stress}m}{\xi_0}}\Gamma\left(1+\frac{g_{stress}m}{\xi_0}\right)$$

$$Y_1=\frac{N_1}{T_{spectrum}}H_1^{g_{stress}m}\left(\ln N_1\right)^{\frac{-g_{stress}m}{\xi_1}}\Gamma\left(1+\frac{g_{stress}m}{\xi_1}\right)$$

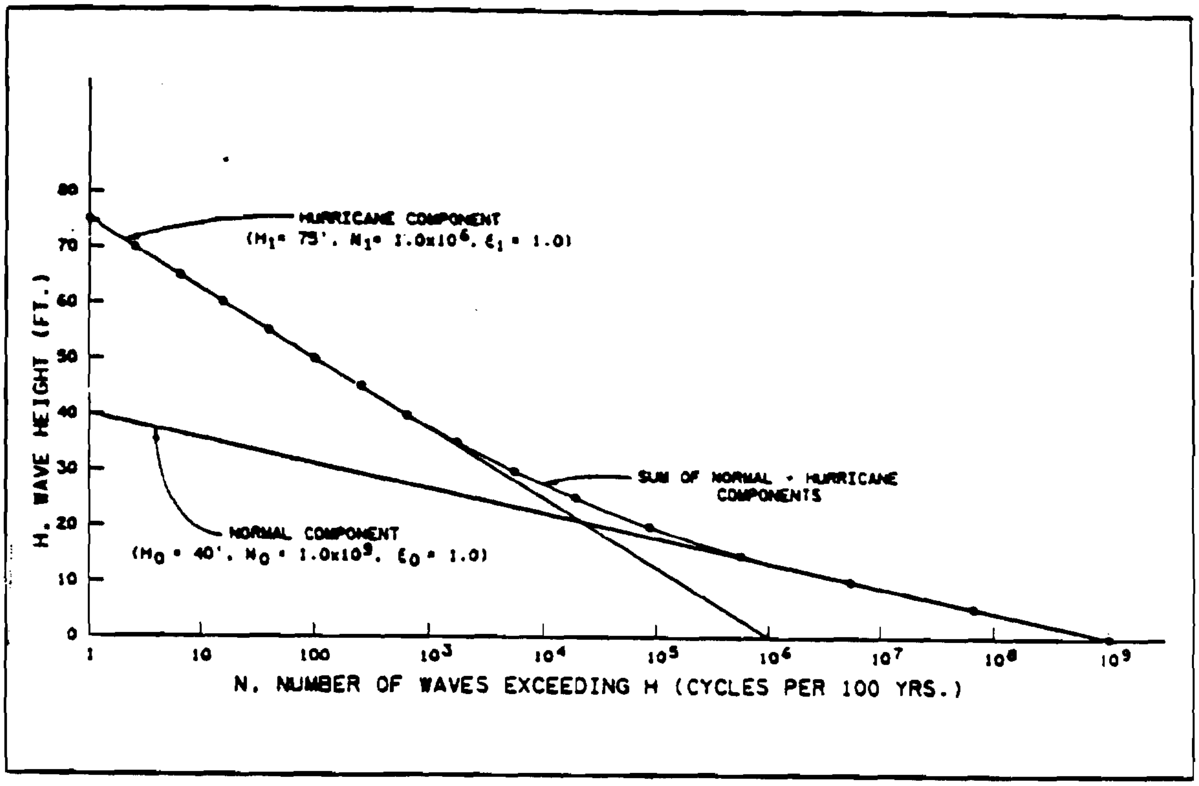
↓

Find S_p for H_f

↓

$$D_d=\frac{T_d}{K}\left(\frac{S_p(1-R)}{H_f^{g_{stress}}}\right)^m\left(Y_0+Y_1\right)$$

Fatigue Analysis with ULSLEA

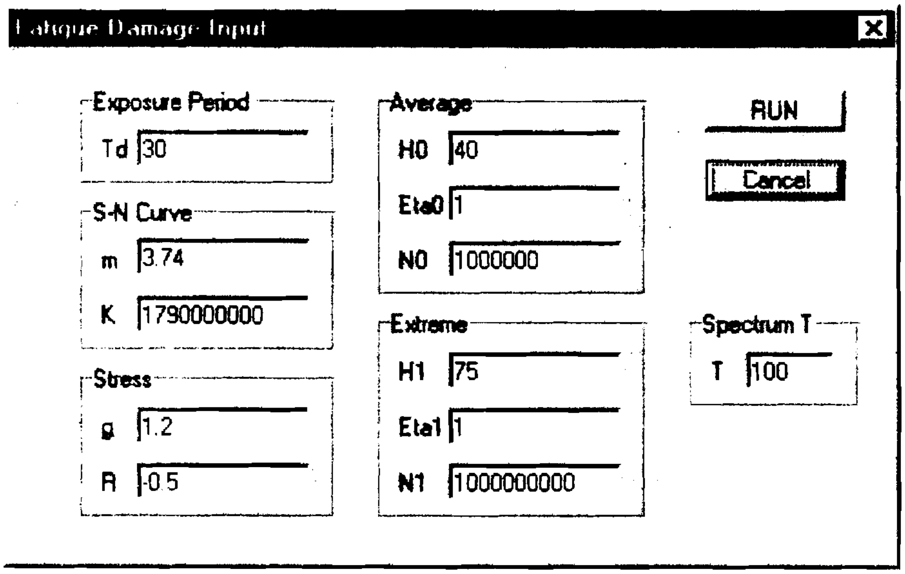


API Wave Height Distribution

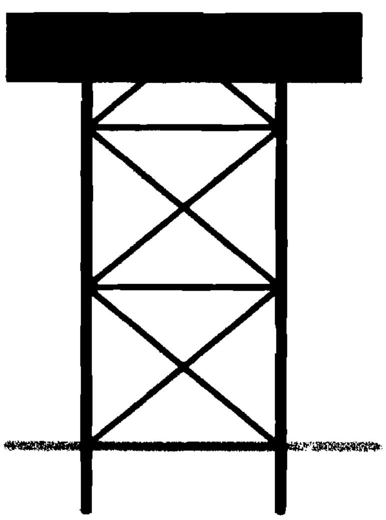
Connection	Axial SCF	In-Plane Bending SCF
Chord K	$1.8\sqrt{\gamma}\tau\sin\theta$	$1.2\sqrt{\gamma}\tau\sin\theta$
Chord T and Y	$3.06\sqrt{\gamma}\tau\sin\theta$	$2.04\sqrt{\gamma}\tau\sin\theta$
Chord X, $\beta < 0.98$	$4.32\sqrt{\gamma}\tau\sin\theta$	$2.88\sqrt{\gamma}\tau\sin\theta$
Chord X, $\beta \geq 0.98$	$3.06\sqrt{\gamma}\tau\sin\theta$	$2.04\sqrt{\gamma}\tau\sin\theta$
All Braces	$1.0 + 0.375\left(1 + \sqrt{\tau/\beta}SCF_{chord}\right) \geq 1.8$	

API Stress Concentration Factors

Fatigue Analysis with ULSLEA

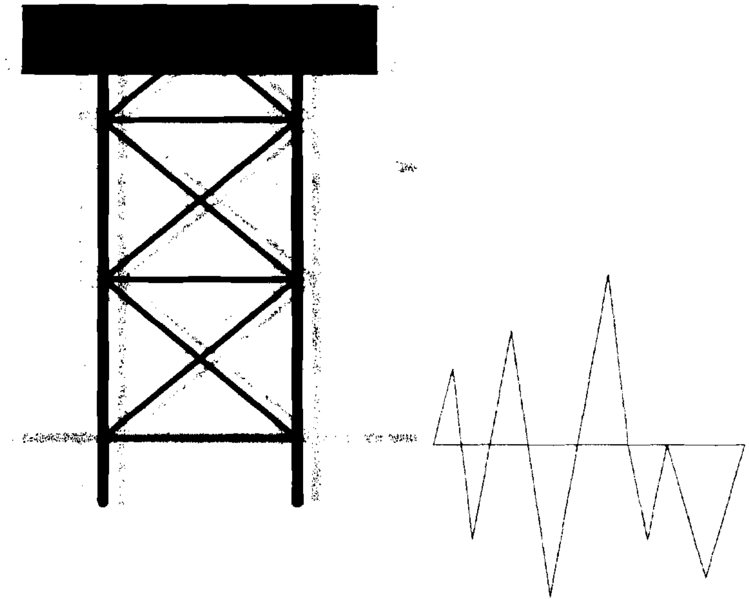


FATIGUE ASSESSMENT
Fatigue Damage Ratings for End-On Tubular Joints



jacket bay #		1		
brace #		joint i	joint j	Ts (years)
	1	0.0317	0.0317	30
	2	0.0317	0.0317	30
	3	0.0317	0.0317	30
	4	0.0317	0.0317	30
jacket bay #		2		
brace #		joint i	joint j	Ts (years)
	1	3.5171	3.5171	9
	2	3.5171	3.5171	9
	3	3.5171	3.5171	9
	4	3.5171	3.5171	9
jacket bay #		3		
brace #		joint i	joint j	Ts (years)
	1	3.1499	3.1499	10
	2	3.1499	3.1499	10
	3	3.1499	3.1499	10
	4	3.1499	3.1499	10

Earthquake Analysis with ULSLEA



Modal analysis to get vibration properties

→ Consult response spectrum to get modal accelerations

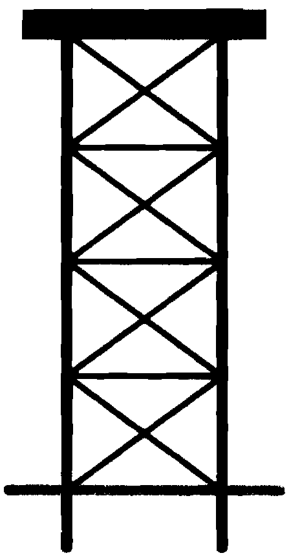
→ Find demands associated with each mode

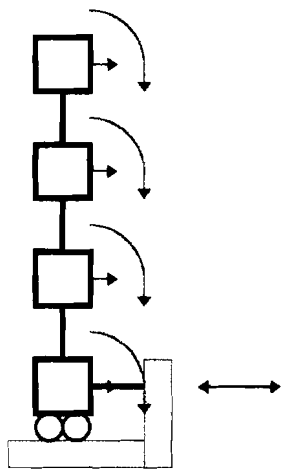
→ Combine modal responses

→ Compare to ULSLEA lower bound

Earthquake Analysis with ULSLEA

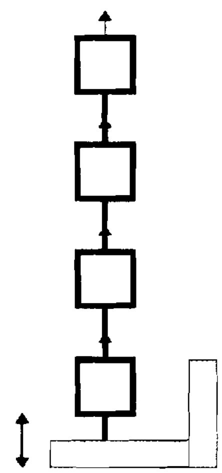
Discrete Models:





Horizontal

"Two"



Vertical

Added Mass:

$$m_{added} = \rho_w \pi r^2 \sin \theta$$

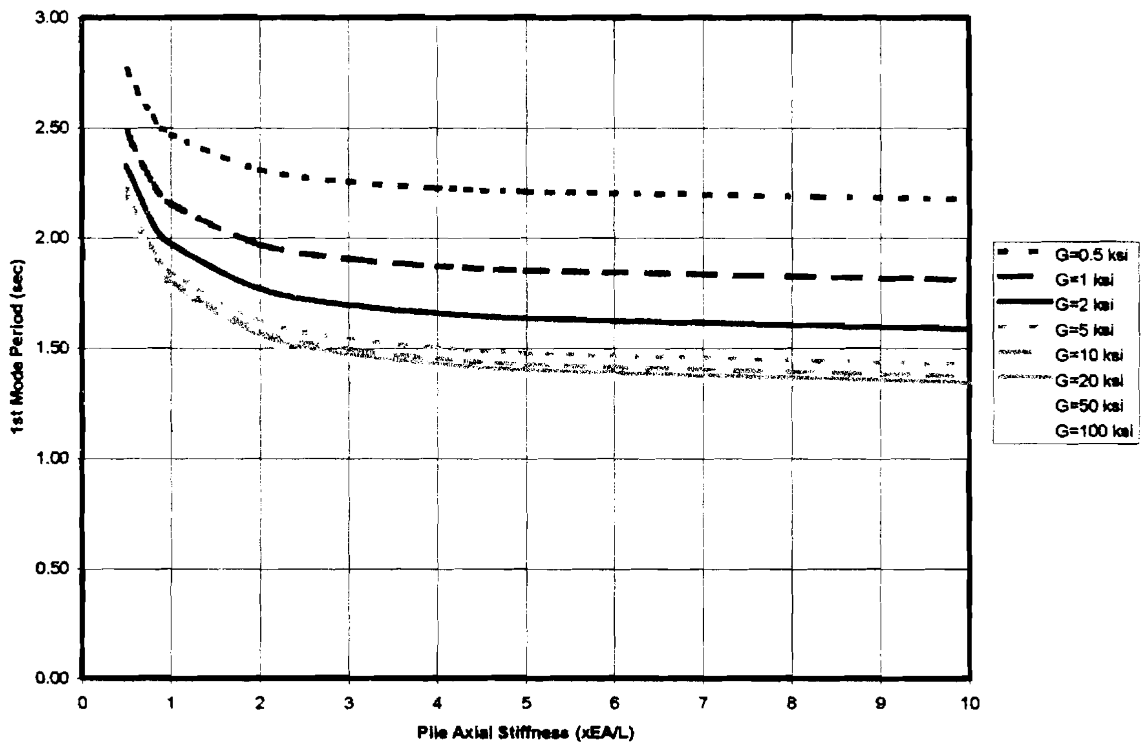
Period Lengthening:

$$\tilde{T}_1 = T_1 \sqrt{1 + \frac{k_1^*}{K_x}\left[\frac{1}{1-(T_o / \tilde{T}_1)^2} + \frac{K_x h_1^{*2}}{K_\theta}\right]}$$

Earthquake Analysis with ULSLEA

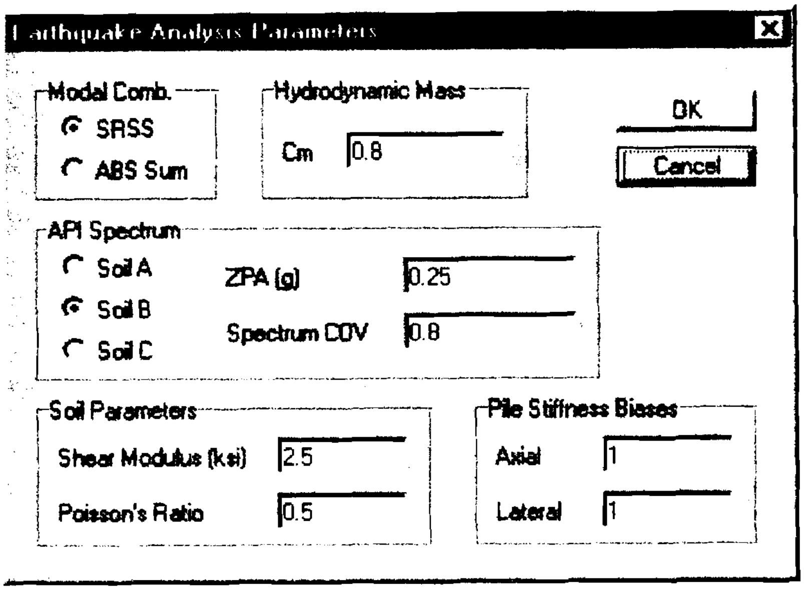
Pile head stiffnesses:

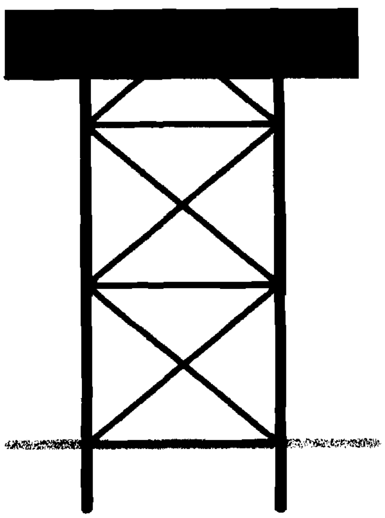
$$k_z = \frac{xEA}{L} \qquad k_x = 18.2Gr\frac{(1-\upsilon^2)}{(2-\upsilon)^2}$$



Foundation Effects on 1st Mode Period

Earthquake Analysis with ULSLEA



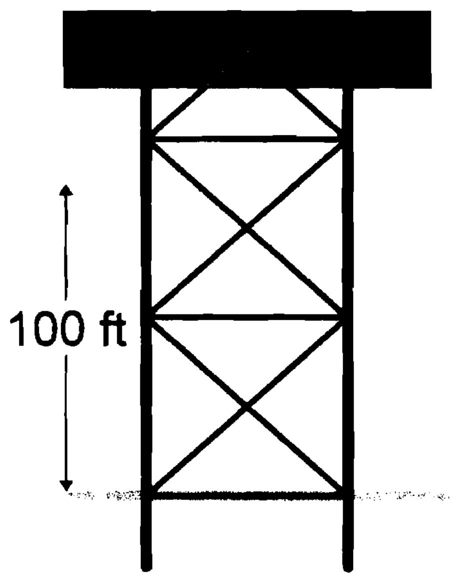


Periods and Mode Shapes

Broadside

Mode		1	2	3
Period (sec)		1.5	0.17	0.09
Deck		1	0.122	0.162
	1	1	0.121	0.158
	2	0.9	-0.122	-1
	3	0.369	-1	0.161

Verification 1: Southern California Test Structure



Hypothetical 4-leg platform

Structure is A36 steel

Main diagonals are 24" and 30" diameter

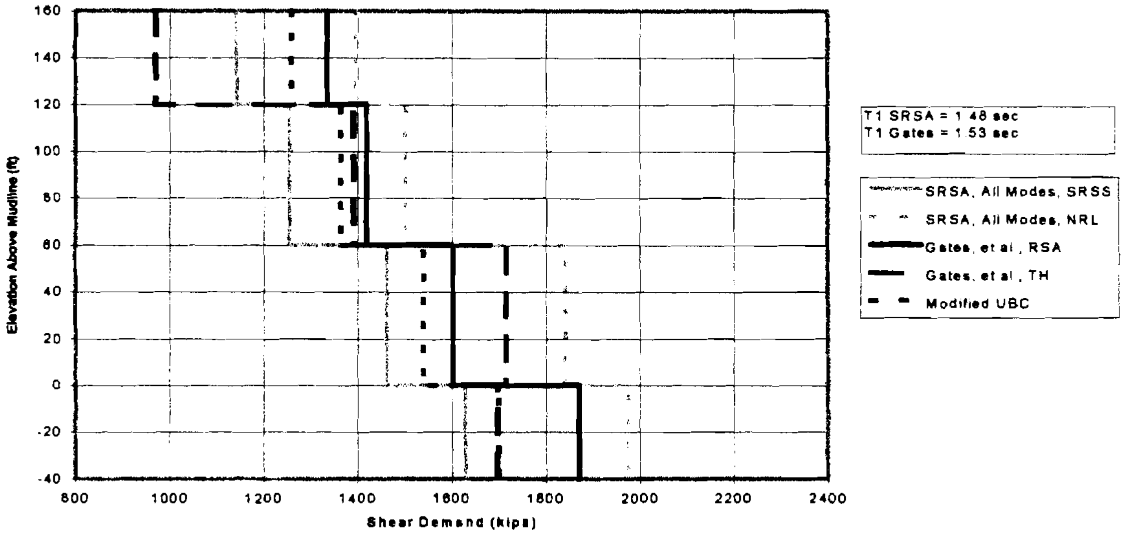
Legs are grouted

72" diameter piles designed for 150' penetration in medium to stiff clay

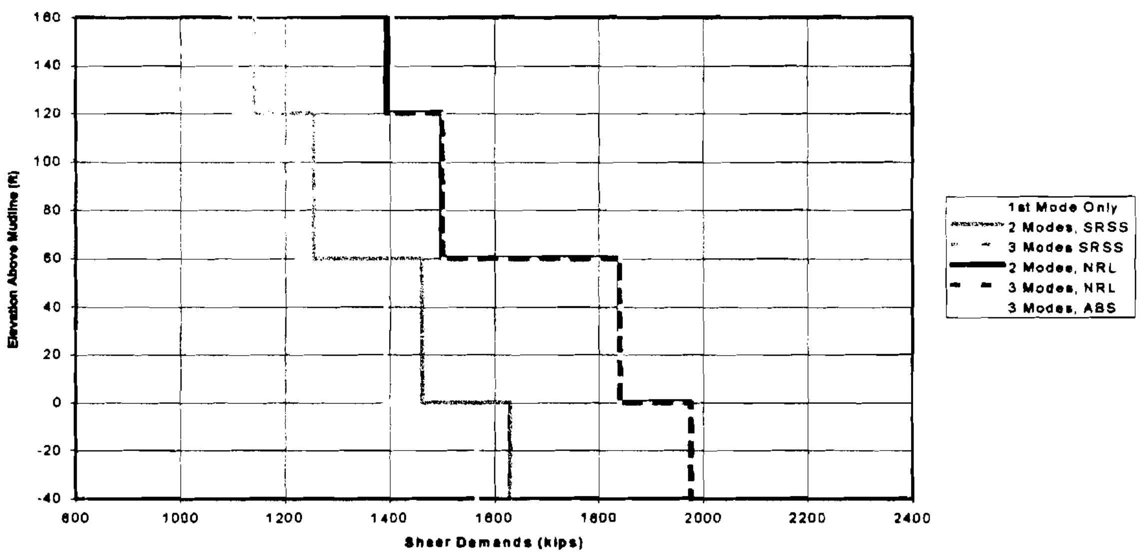
Analyzed by Gates, et al., using both time-history and RSA

Verification uses API spectrum, 5% damping, soil B, ZPA = 0.25 g

Verification 1: Results

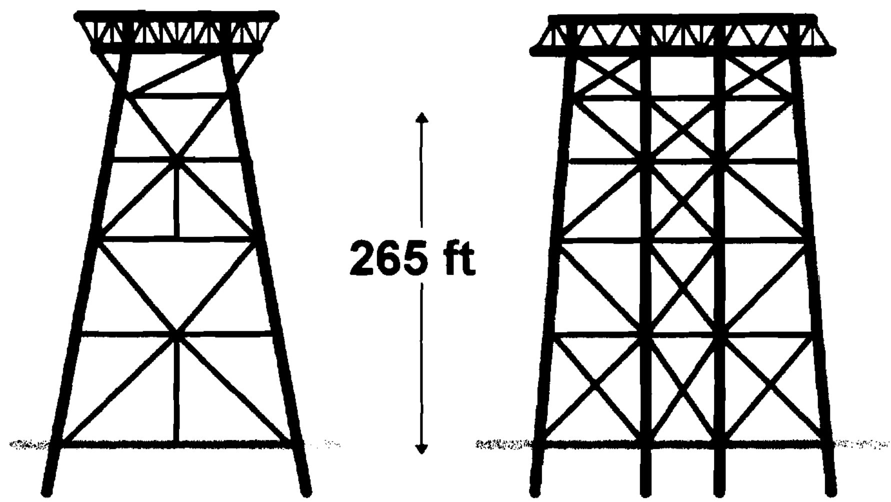


Comparison of Shear Demands



Modal Contributions

Verification 2: Platform Ellen



8-leg drilling platform

Majority of structure is 36 ksi, with 50 ksi piles

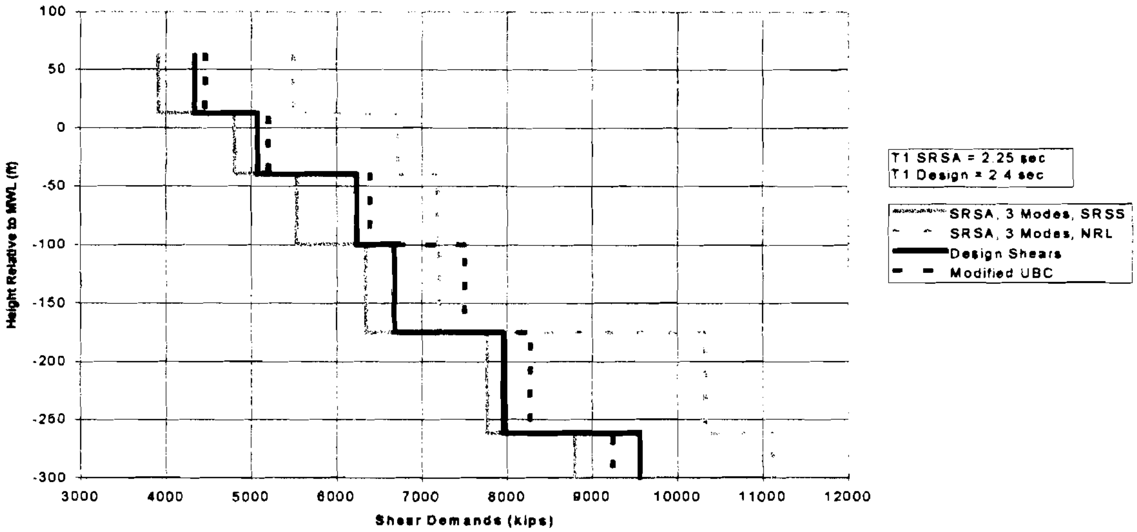
Main diagonals range 20" to 30" diameter

Legs are ungrouted

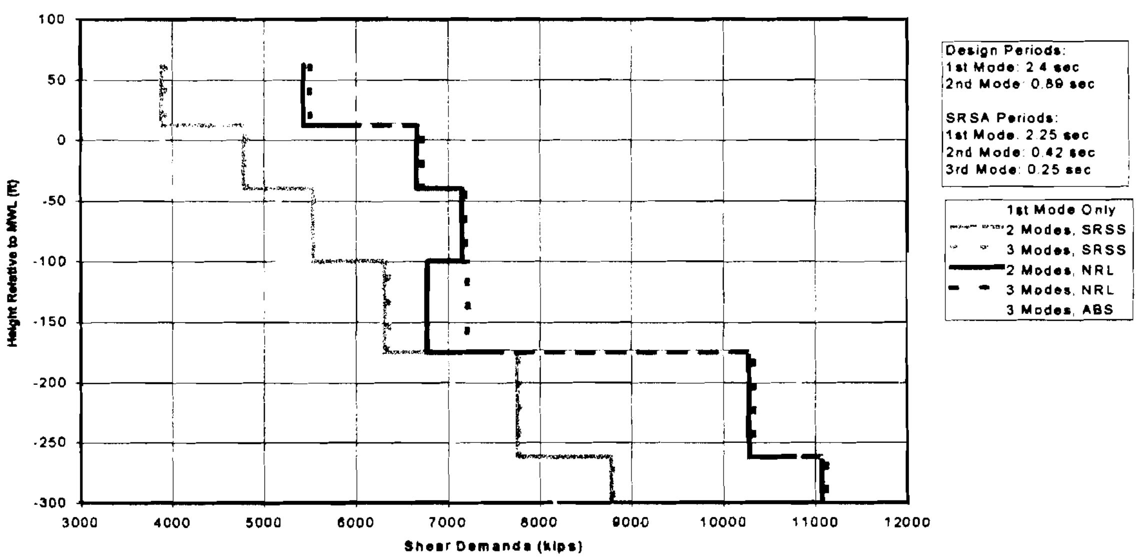
48" and 66" diameter piles driven to 232' and 264' in medium to stiff clays and silts

Verification uses API spectrum, 5% damping, soil C, ZPA = 0.25 g

Verification 2: Broadside Response

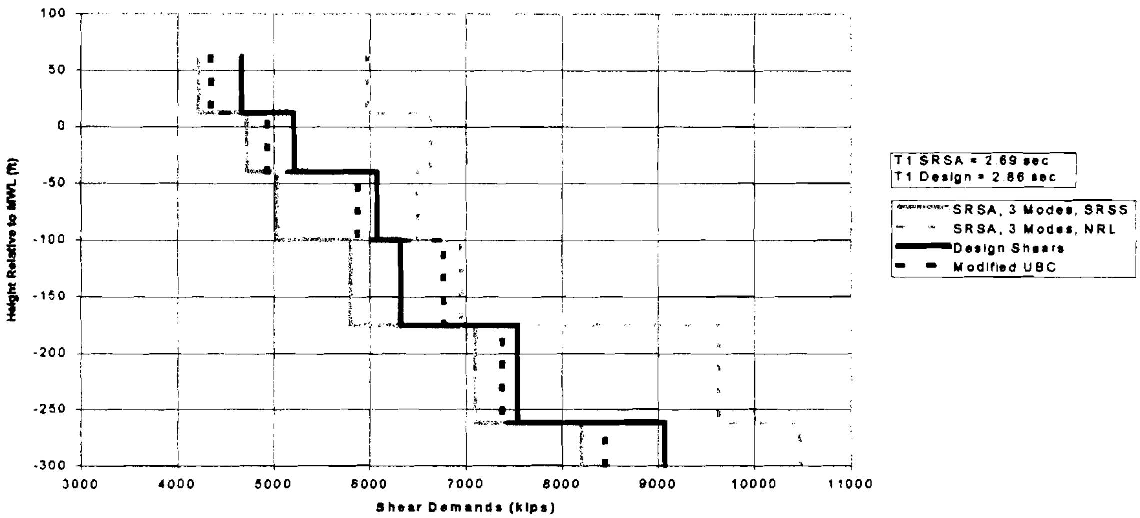


Broadside Shear Demands

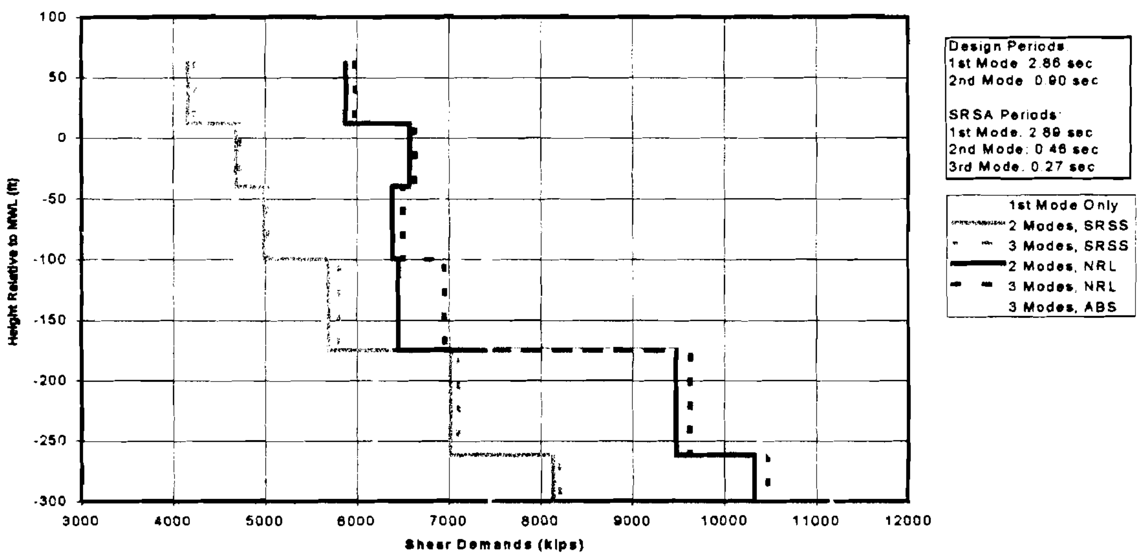


Modal Contributions to Broadside Demands

Verification 2: End-On Response

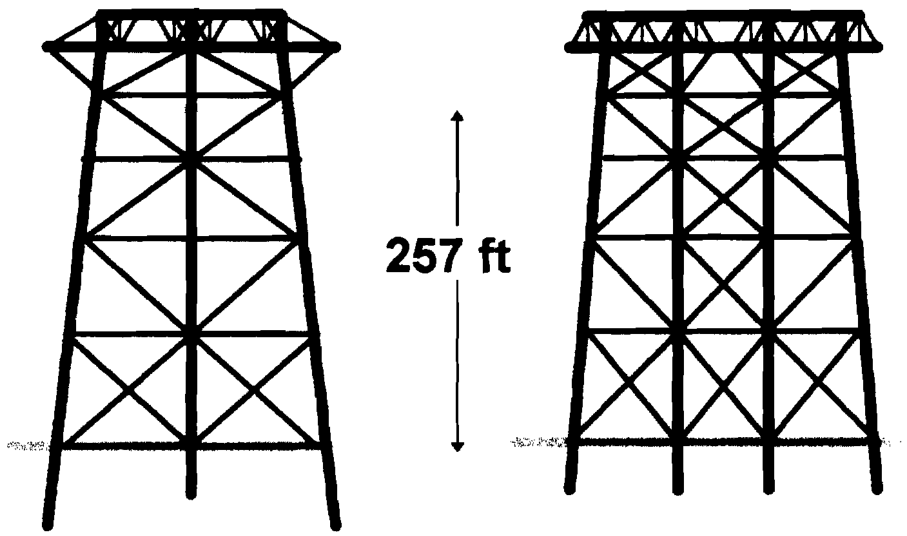


End-On Shear Demands



Modal Contributions to End-On Demands

Verification 3: Platform Elly



12-leg drilling platform

Majority of structure is 36 ksi, with 42 ksi piles

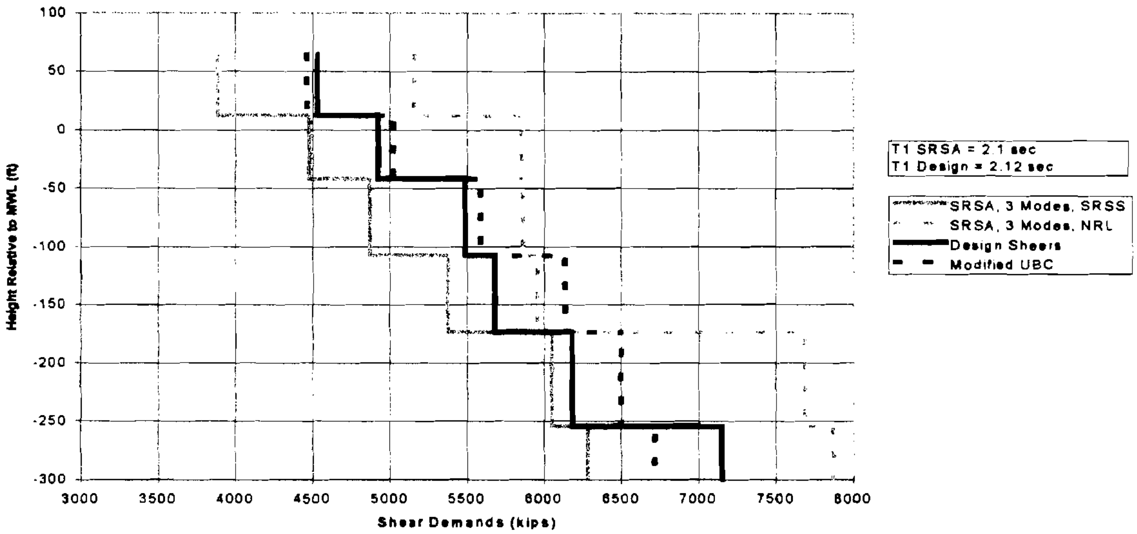
Main diagonals range 24" to 36" diameter

Legs are ungrouted

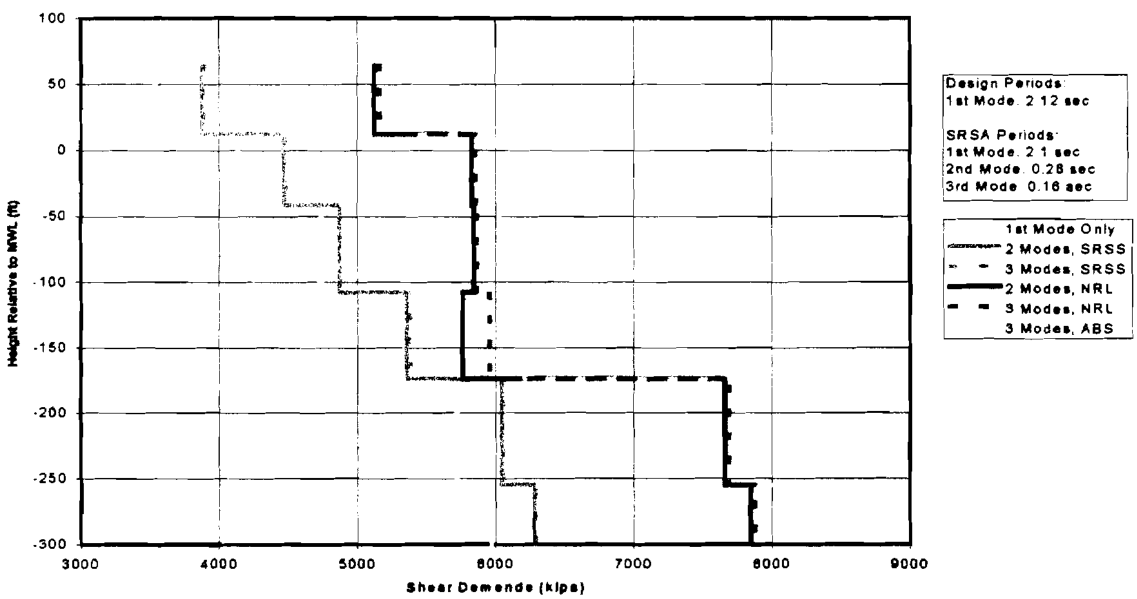
42" and 48" diameter piles driven to 200' to 252' in medium to stiff clays and silts

Verification uses API spectrum, 5% damping, soil C, ZPA = 0.25 g

Verification 3: Broadside Response

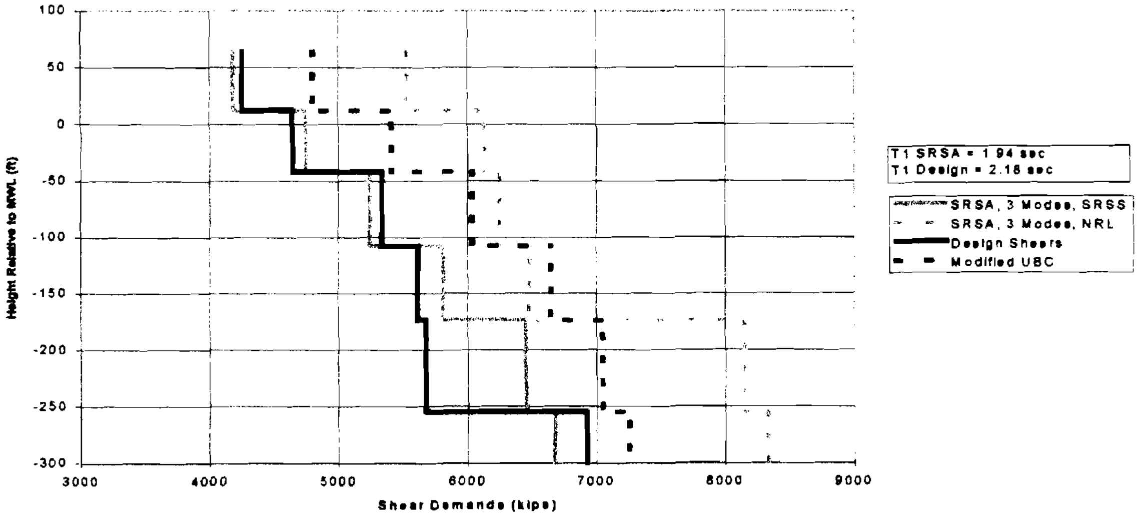


Broadside Shear Demands

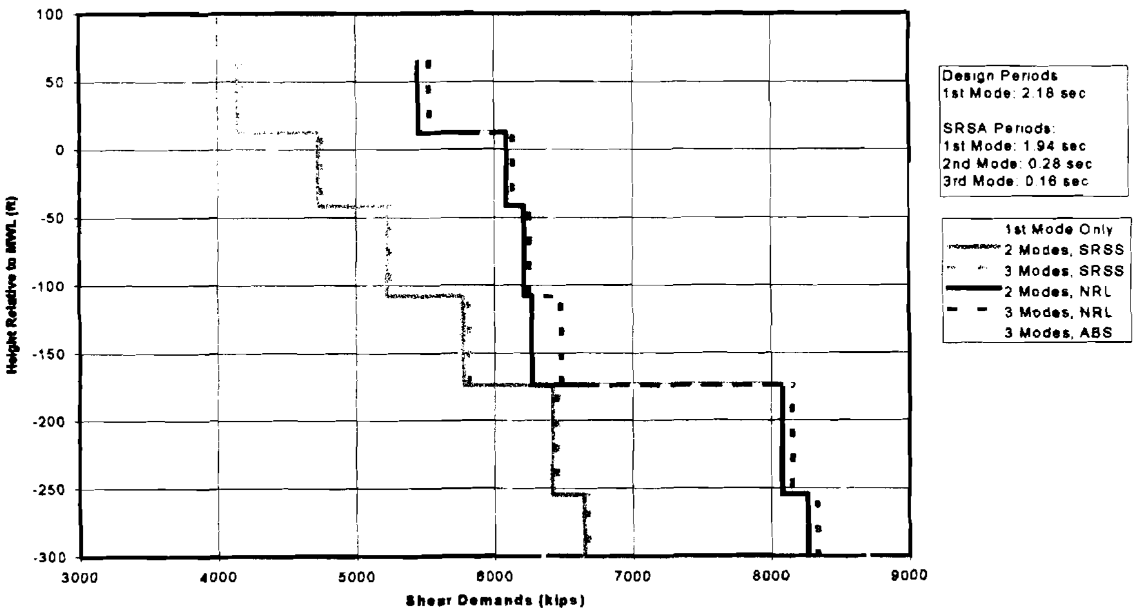


Modal Contributions to Broadside Demands

Verification 3: End-On Response

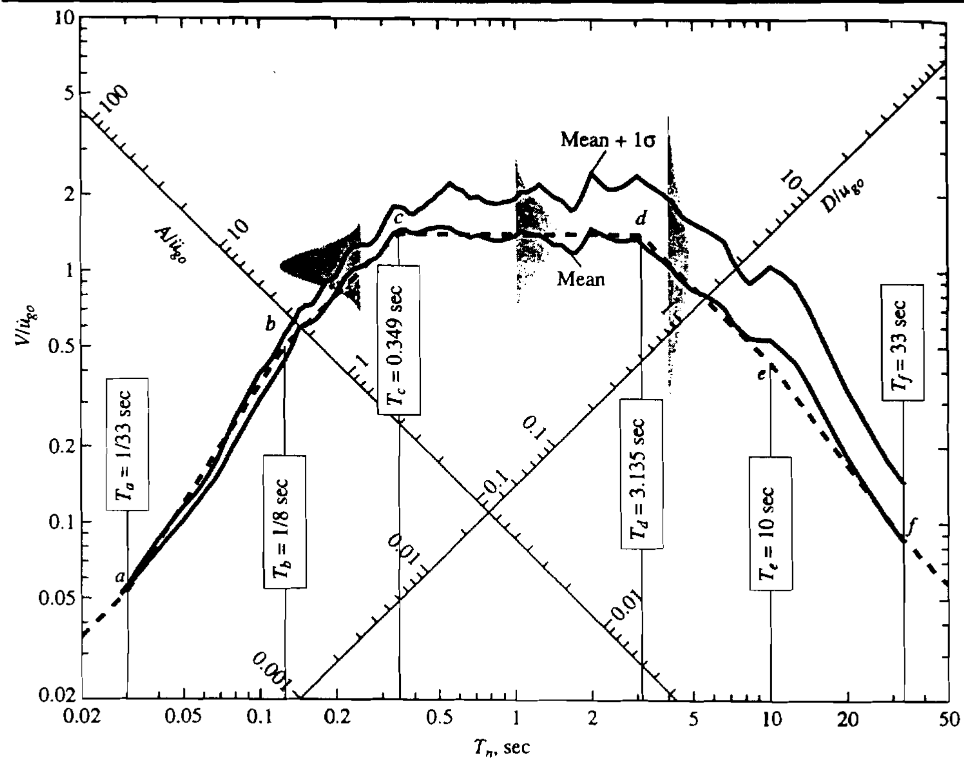


End-On Shear Demands



Modal Contributions to End-On Demands

Reliability and Earthquakes



Uncertainty in Response Spectrum Ordinates

Safety index formulation:

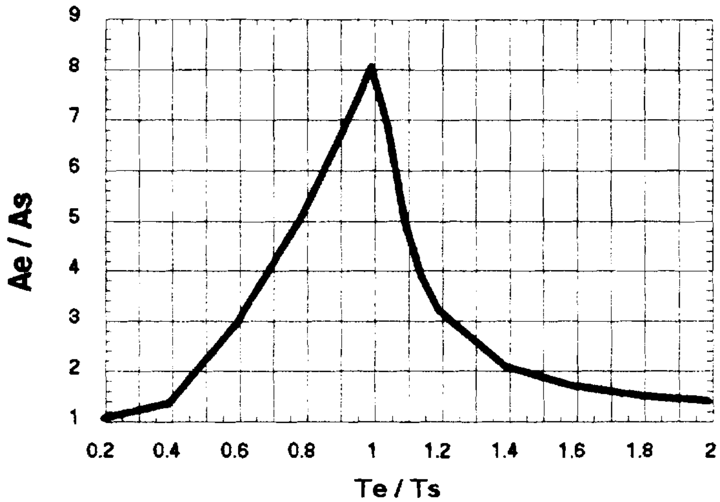
$$\beta = \frac{\mu_M}{\sigma_M} \qquad \mu_M = \ln\left(\frac{\mu_R}{\mu_S} \sqrt{\frac{1+V_S^2}{1+V_R^2}} \right)$$

$$\sigma_M^2 = \ln\left(1+V_R^2\right) + \ln\left(1+V_S^2\right) - 2\ln\left(1+\rho_{RS}V_R V_S\right)$$

If spectrum is deterministic:

$$\sigma_T^2 = \sigma_M^2\left(\frac{\partial T}{\partial T_M}\right)^2 + \sigma_{K_x}^2\left(\frac{\partial T}{\partial K_x}\right)^2 + \sigma_{K_\vartheta}^2\left(\frac{\partial T}{\partial K_\vartheta}\right)^2$$

Accelerations for Equipment



Amplification Ratio

$T_{ej}/T_{si} < 1.25$

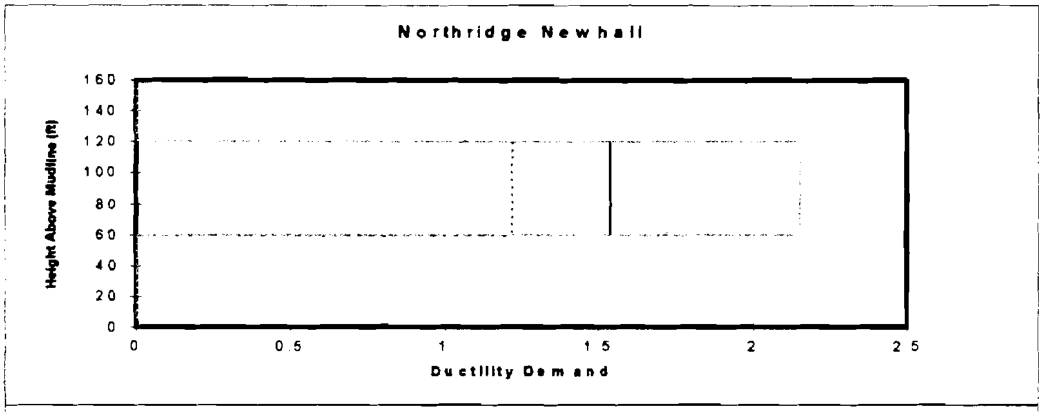
$$\ddot{u}_{ij}' = \left(\frac{A_{ej}}{A_{si}}\right)\ddot{u}_{xi}$$

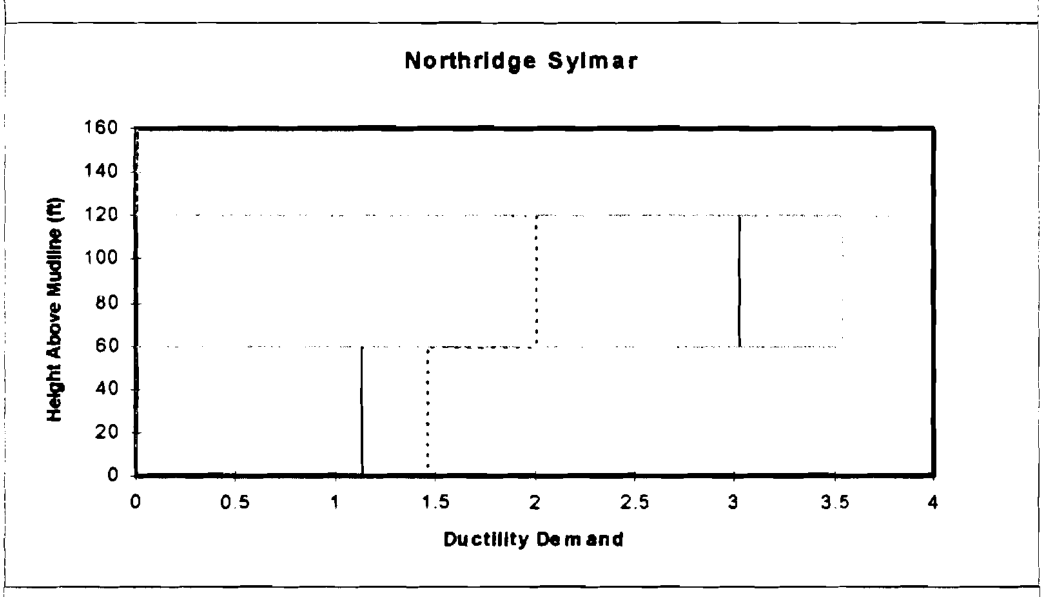
$T_{ej}/T_{si} \geq 1.25$

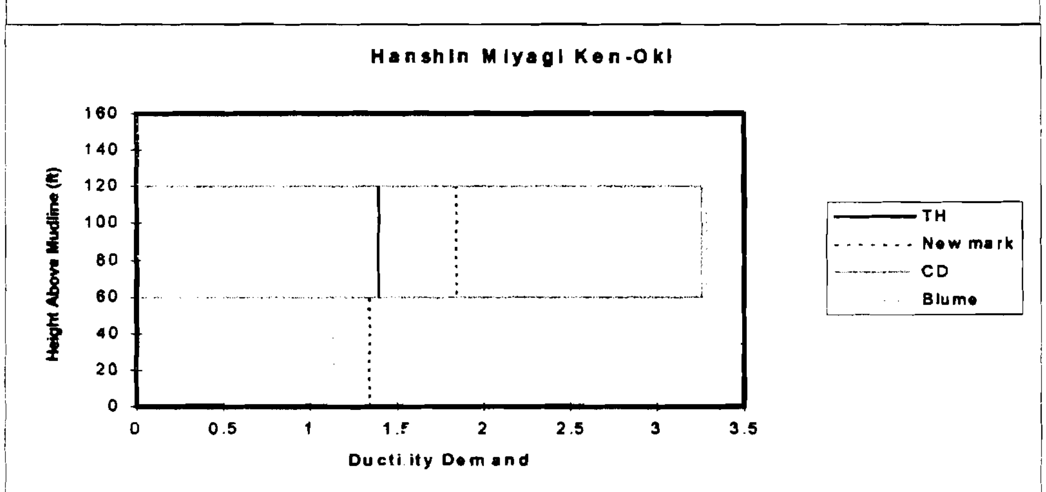
$$\ddot{u}_{ij}'' = \left(\frac{A_{ej}}{A_{si}}\right)SA_j$$

$$\ddot{u}_j = \sqrt{\sum_{i \text{ over all } \ddot{u}'} \left(\ddot{u}_{ij}'\right)^2 + \frac{\sum_{i \text{ over all } \ddot{u}''} \left(\Gamma_i \phi_{xi} \ddot{u}_{ij}''\right)^2}{\sum_{i \text{ overall all structure modes}} \left(\Gamma_i \phi_{xi}\right)^2}}$$

Ductility-Level Analysis

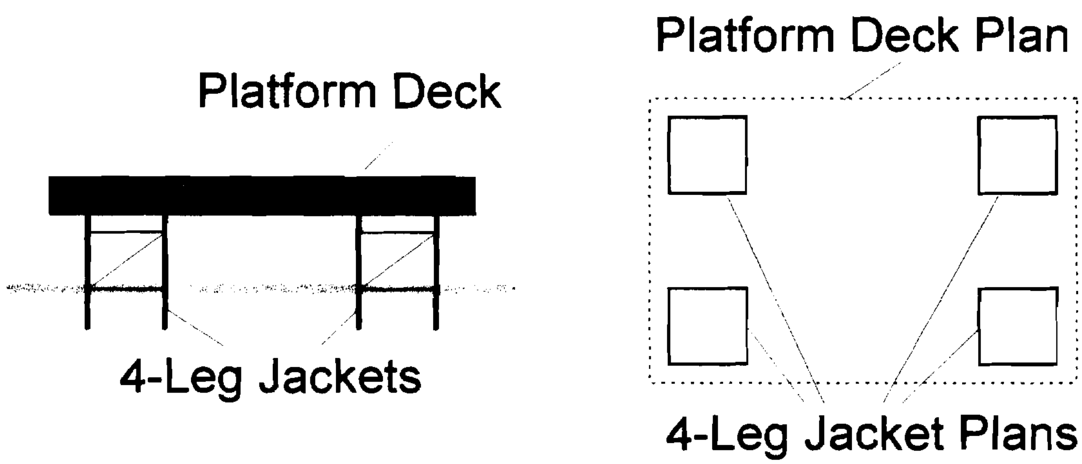


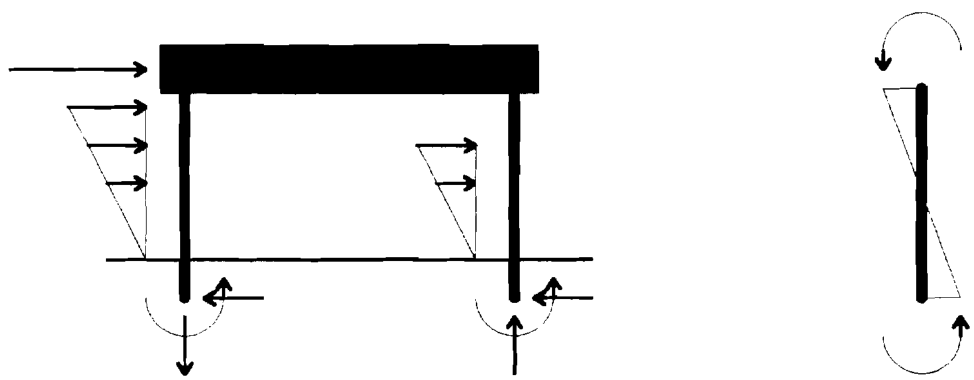




Additional Configurations

Multi 4-leg jackets:



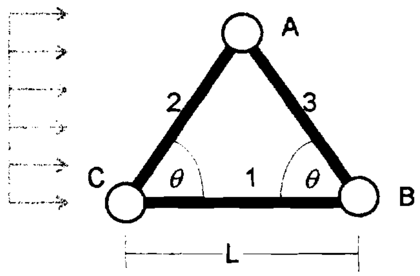


Multi-jacket Behavior

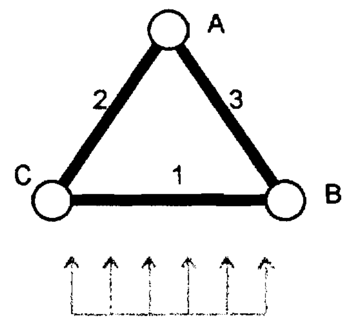
Additional Configurations

Tripod Jackets:

Broadside Load



End-On Load



Broadside Jacket Capacity:

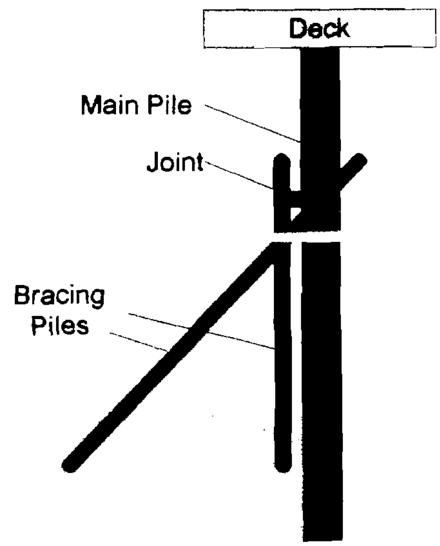
$$P_{u\,H_{bay}} = P_{u\,H_{MLTF\,Frame\,1}} + \left(\frac{P_{u\,H_{MLTF\,Frame\,1}}}{k_{H_{MLTF\,Frame\,1}}} \right) k_{H_{Frame\,1}} + \sum \left(\frac{P_{u\,H_{MLTF\,Frame\,1}}}{k_{H_{MLTF\,Frame\,1}}} \right) k_{H_{Frames\,2,3}} \cos^2 \theta$$

End-On Jacket Capacity:

$$P_{u\,H_{bay}} = P_{u\,H_{MLTF\,Frames\,2,3}} \sin\theta + \sum \left(\frac{P_{u\,H_{MLTF\,Frames\,2,3}}}{k_{H_{MLTF\,Frames\,2,3}}} \right) k_{H_{Frames\,2,3}} \sin\theta$$

Additional Configurations

Braced Monopods (Caissons):



Capacity of unsupported section:

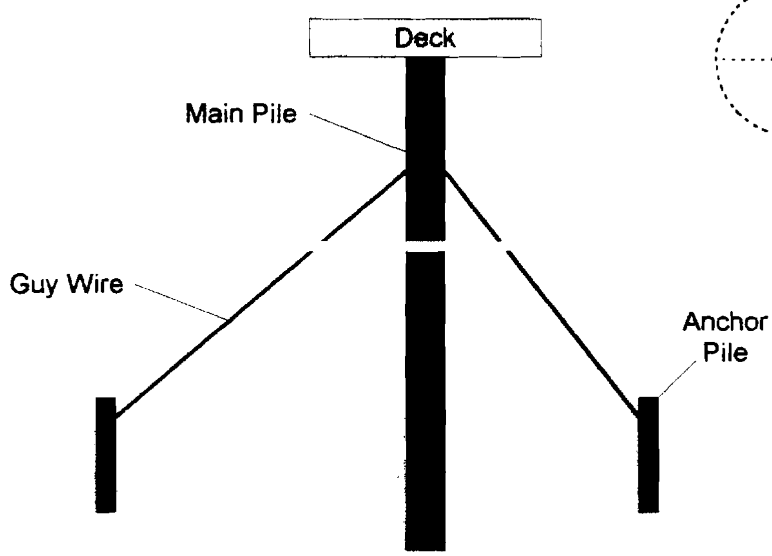
$$P_{uH} = \frac{(M_u - Q\Delta)}{H_d}$$

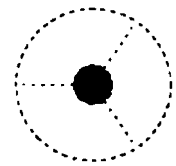
Capacity of brace:

$$P_{uH} = P_{uH_{brace}} + \frac{P_{uH_{brace}}}{k_{H_{brace}}} k_{H_{main\ pile}} - \frac{3M}{2H_u}$$

Additional Configurations

Guyed Monopods (Caissons):





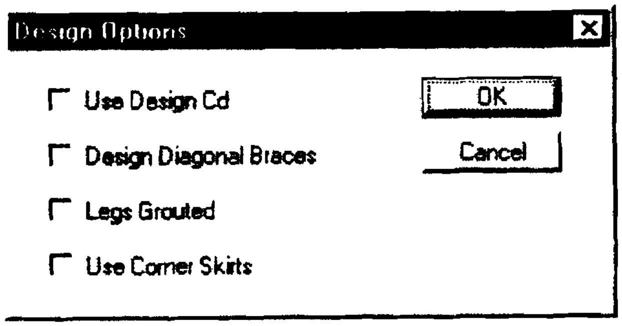
Capacity of guy wire system:

$$P_{uH} = P_{uH_{\text{guy wire}}} + \frac{P_{uH_{\text{guy wire}}}}{k_{H_{\text{guy wire}}}} k_{H_{\text{main pile}}} - \frac{3M}{2H_u} - F_{pretension} \cos\theta$$

ULSLEA Program Development

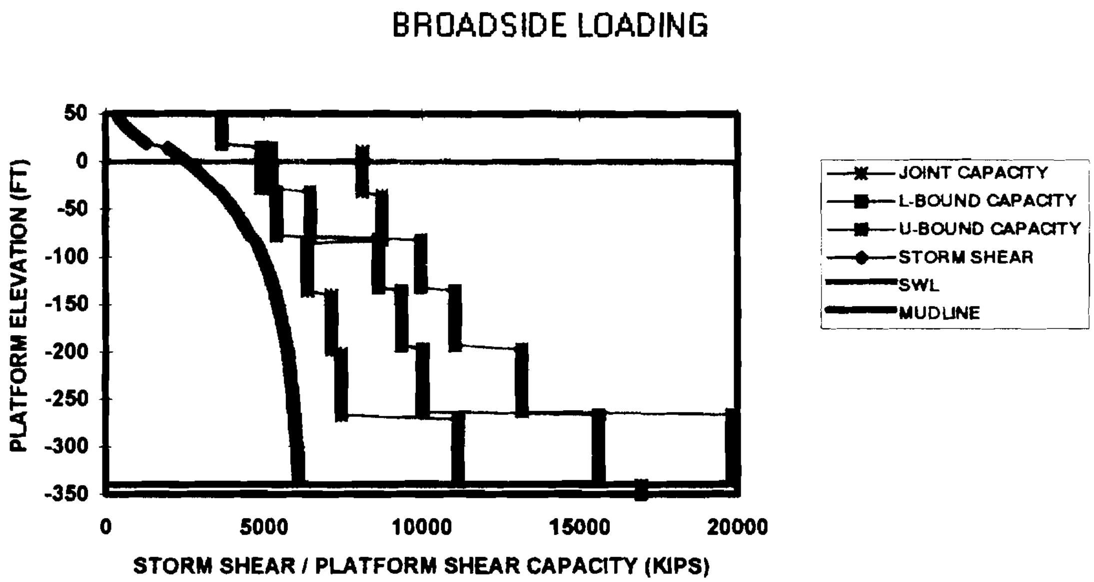
- Coding finished for Phase III commitments
- v3.0 runs with MS Excel 5.0 in MS Windows environment (Win95 and Office97 recommended)
- Machine requirements are 32 MB RAM and Pentium/90 processor or better

Basic Program Enhancements

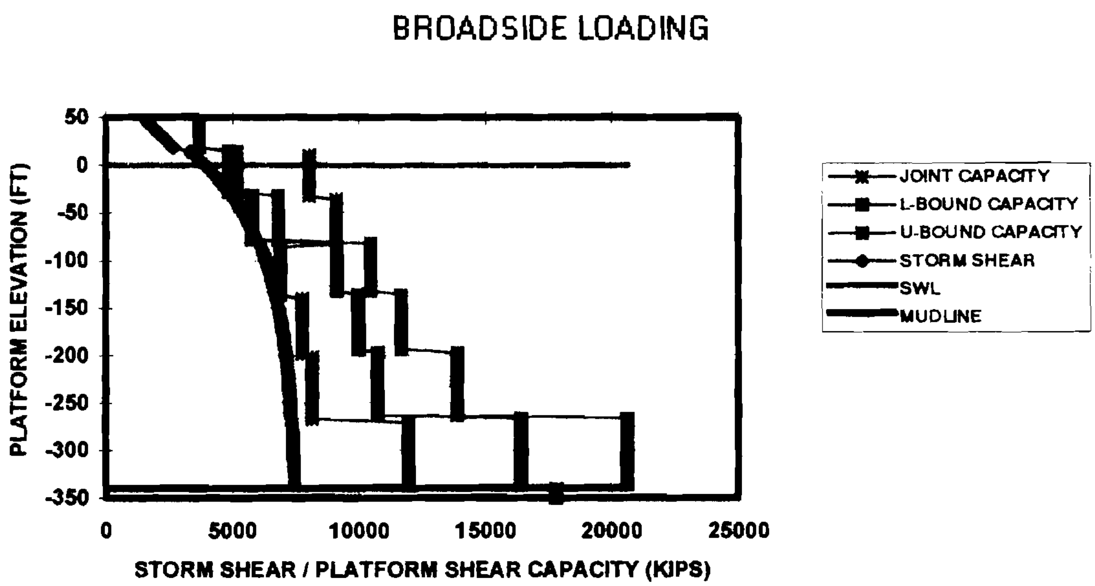


- Drag/added mass coefficient scaling
- Grouting of legs
- Corner skirt piles
- Braced deck bay

Drag Coefficient Scaling: SP 62 A



C_d SCALING



NO SCALING

Phase IV Project Goals

- Parameter studies (3 platforms)
- Development of ductility-level earthquake analysis routines
- Diagonal loading formulations and capacity formulations for elements sensitive to diagonal loads
- Adaptation of the program to allow for the analysis of 4-leg structures with one vertical face, and tripod structures with one vertical leg
- Developing and documenting updated biases and uncertainties for joints, braces, and piles
- Adapting the program interface to allow for the input of separate yield strengths for individual components of the structure (joint cans, braces)
- Improved graphical and printed output
- Foundation elements allowing for layered soils, and contributions to stiffness and capacity from mud mats, mudline braces, and conductors
- Algorithms allowing a user to calculate reliability sensitivity factors
- Spatial variation of wave forces for platforms with large dimensions
- Shallow water wave kinematics
- Vertical loads and loading capacities for deck structures

Phase IV Project Plan

Task/Description/GSR	1997		1998	
	6	12	1	5
1 - Damage studies *New*	----------		------------------x	
2 - Dynamics *Stear*	-------------------		------------------x	
3 - Diagonal loads *Stear, Jin*			-------x	
4 - Configurations *Stear*	---------------x			
5 - Uncertainties *Jin, Xu*	-------------------		-------------x	
6 - Joints *Stear*	---------x			
7 - Improved output *Stear, Jin*	-------------------		-------x	
8 - Foundations *Stear, Jin*	-------------------		------------------x	
9 - Reliability *Jin*			------x	
10 - Wave spatial *New*	--------		-x	
11 - Kinematics *Jin*	--------		-x	
12 - Deck elements *New*			------------------x	
Meetings	x		x	x